The TOPEX Sigma0 Calibration Table and its Updates

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INTRODUCTION

From launch and continuing throughout the life of the TOPEX/Poseidon mission, our group at Wallops Flight Facility (WFF) has been conducting performance analysis and engineering assessment for the TOPEX/Poseidon mission's NASA radar altimeter, hereafter referred to simply as the TOPEX altimeter. Among the TOPEX altimeter's output products are estimates of the ocean surface's normalized backscattering cross section (designated as sigma0, for typographical convenience). We have earlier described calibration changes for the TOPEX altimeter Ku- and C-band sigma0 estimates in Callahan *et al*. [1994]. After more than two years of additional TOPEX data we reexamine the sigma0 calibration issue, and this report is intended as an update and replacement for the earlier paper.

For an over-ocean radar altimeter whose transmitted power is constant, the received back-scattered power is proportional to sigma0. As the altimeter ages, its transmitted power tends to drift slowly (usually downward) by a dB or two, its receiver characteristics also can drift, and it is necessary to account for these drifts in power estimation when calculating sigma0 estimates from the altimeter data.

In TOPEX ground data processing for the intermediate geophysical data record (IGDR) there is a sigma0 calibration table which, for each TOPEX data cycle, contains one additive correction for the Ku-band sigma0 and one additive correction for the C-band sigma0. We will refer to the sigma0 calibration table as the CalTable in the following. The power estimation drift is slow enough that for any data cycle the CalTable values do not change for any passes within the cycle but need to be changed only every several cycles.

At launch the CalTable values were zero for both Ku- and C-band. We had expected to provide CalTable updates based on calibration mode data. When by data cycle 048 it became clear that the CalTable values needed to be updated, the calibration mode results disagreed somewhat with cycle averages of global over-ocean sigma0, and we decided to make the CalTable update based on the trend in the global over-ocean sigma0(uncorr). By sigma0(uncorr), we mean the GDR sigma0 value with the CalTable correction removed. In effect, the sigma0(uncorr) is the GDR sigma0 which would have been produced if all the CalTable values had been zero when producing the GDR.

For the first three years of TOPEX data both the Ku- and the C-band global sigma0(uncorr) appeared to decrease linearly with time (or with data cycle number), although with different slopes. Recently the slopes have seemed steeper (*i.e.*, the slope values have become more negative) so that now, after four years of TOPEX data, some polynomial degree higher than linear is necessary to describe the sigma0(uncorr) time trends.

This paper will describe the CalTable values actually used in producing the TOPEX GDR, as well as our current best estimates of what those values should have been. After briefly describing the TOPEX calibration mode, we compare calibration mode data with the sigma0(uncorr) data. We describe how the CalTable values are documented and how to find what CalTable values were used for each TOPEX cycle's GDR production. We then describe the time trend fitting for the sigma0(uncorr) data, and provide a table which will enable the TOPEX data user to improve the sigma0 estimates from the GDR.

THE TOPEX ALTIMETER'S INTERNAL CALIBRATION MODE

The TOPEX altimeter's internal calibration mode has two submodes referred to as Cal-1 and Cal-2. In Cal-1 a portion of the transmitter output is fed back to the receiver through a digitally controlled calibration attenuator and a delay line. The altimeter acquires and tracks this calibration signal for 10 seconds for each of 17 different preset attenuator values (each step change is 2 dB). The altimeter's automatic gain control (AGC) loop is active during each Cal-1 step, so Cal-1 should provide information on changes in the altimeter's range and power estimation. The altimeter's Cal-1 and its normal fine-track mode have the same hardware except that Cal-1 has a delay line, a different attenuator, and switches to select these components; in principle the Cal-1 AGC measurements should be directly relatable to changes in the altimeter's power estimation In Cal-2 the altimeter processes receiver thermal noise, with no transmitted signal present, primarily to characterize the waveform sampler response but Cal-2 should also provide additional information on the received power estimation.

When commanded to the calibration mode, the TOPEX altimeter first enters Cal-1 and then Cal-2. Cal-1 has 17 different steps, each lasting about 10 seconds, and Cal-2 lasts about a minute, so the entire calibration mode lasts about 4 minutes. There are normally two calibration modes commanded in each day of TOPEX altimeter operation, and these calibrations are scheduled over land to avoid loss of ocean data.

CALIBRATION MODE RESULTS COMPARED WITH UNCORRECTED GLOBAL SIGMA0 AVERAGES

Routine WFF processing and databases for TOPEX

As part of our continuing TOPEX support, we do daily quick-look processing of all TOPEX altimeter data for performance monitoring, providing performance summaries for the engineering

and science data. The daily processing results are used to update a launch-to-date engineering database. Also the daily (two sets of) calibration mode data are processed and the results used to update a WFF launch-to-date calibration database. We also process the intermediate geophysical data record (IGDR) data as they become available for network access, normally several days after the altimeter acquires the data. The IGDR data are processed for altimeter performance, and 1-minute summary records are produced and are added to a WFF launch-to-date IGDR database. When the GDR data become available, they replace the IGDR data already in our database. There is no difference, however, between sigma0 data on the IGDR and the GDR, because no further sigma0 corrections are made in going from the IGDR to the GDR.

We have been very concerned about contamination of the data by what we have come to call "sigma0 blooms", regions of over-ocean altimeter data characterized by unusually high apparent sigma0 values accompanied by unusual altimeter waveform shapes. Generally the Ku-and the C-band sigma0 show the same behavior in a bloom region. Such blooms in the TOPEX data can persist for several tens of seconds, and the waveforms in a bloom region generally have too rapid a plateau decay. Many of these waveforms are too sharply peaked ("specular") indicating a breakdown in the general incoherent scattering theory used to characterize the rough surface scattering. The sigma0 blooms exist in perhaps 5% of all TOPEX over-ocean data (there is additional sigma0 bloom information on the WFF TOPEX group's web page at the address http://osb3.wff.nasa.gov/topex/blooms/blooms.html). For input to our GDR database 1-minute averages, we require all the available altimeter flags to show normal tracking and the land/water flag to show deep water. When the data are extracted from this database for the sigma0 calibration, all records are rejected that have Ku-band sigma0 estimates of 16 dB or greater or that have waveform-estimated attitude angles of 0.12 degrees or greater.

Discussion of Documentation of CalTable Changes

Because our analysis is based on sigma0(uncorr), we need to know what CalTable values have been already applied to the GDR (or IGDR) data in order to "undo" these corrections. There have been more than a dozen CalTable adjustments over the TOPEX lifetime, as discussed briefly in a later section of this paper "History of CalTable Values Used in GDR Production". There exists no single summary of exactly when each of the CalTable changes was implemented in the TOPEX ground processing, so we will try to provide that summary here.

Each time that the CalTable contents are changed in the TOPEX ground data processing at JPL, there are at least these three items created:

* The MOS Change Request Form (the MCR) has an origination date, describes the change to be made and the desired operational date for the change, and has the date when the MCR was approved (by a change control board at JPL).
* The Parameter File is the text file to be actually used in the data processing and containing the CalTable values for each cycle.
* The File Release Form contains the Parameter File creation date, the release approval date, and the date at which file execution is to begin.

The MCR Form is usually accompanied by other supporting information from WFF describing why the change is being requested, but what is being discussed now is not why but when the change was actually implemented. We have obtained from JPL copies of all the sigma0-related MCRs and File Release Forms, and have summarized the information from these in Table 1. Columns 1 to 4 of Table 1 are transcribed from the MCR Forms, columns 5 to 7 from the File Release Forms, and column 8 contains a brief indication of what change the MCR made and why.

From only the information summarized in Table 1, it is not possible to completely and unambiguously determine what MCR applied to each TOPEX cycle. This is in part because some of the File Release Form's dates at which file execution was to begin indicated dates earlier than the Parameter File's creation date, to accommodate cycle reprocessing. Also the creation date of the Parameter File was only the date at which the information was entered into a file at some off-line terminal, and was not the date at which the Parameter File was actually installed in the data processing. The TOPEX processing records the processing software version number to the GDR file header, but it is unfortunate that no provision was made for entering the CalTable version number to the header. From a production processing database at JPL, Frank Salamone recently supplied us with dates at which the IGDRs were created for specified passes within each data cycle, and with this additional information the MCR ambiguity could be resolved. Column 9 of Table 1 lists our best estimate of the TOPEX cycles governed by each MCR and, since we have the Parameter File values for each MCR, we now know what CalTable values were in place for each cycle's GDR production.

Comparison of results from WFF calibration database and IGDR database

Figures 1a and 1b show our Ku- and C-band calibration database and GDR database comparisons for TOPEX cycle-averages. The several curves in Figure 1a and 1b have been shifted in order to be plotted on common y-axes, and the Figure legend indicates the shift value. In all discussions of sigma0(uncorr) trends, the TOPEX cycles 1 - 10 should be ignored, because of early operational procedures. The sigma0(uncorr) results plotted in Figures 1a and 1b have been corrected for a significant waveheight (SWH) effect using results of the trend fit described later. This SWH correction reduces the scatter of points in the figure but does not change the overall trends shown. Only one of the Cal-1 steps, Step 5, is shown because Step 5 operates at an altimeter AGC level close to that of normal over-ocean tracking; however, the other Cal-1 steps show the same general trends as Step 5.

In the Ku-band results in Figure 1a, the sigma0(uncorr) trend is shown by the solid dots. The Ku-band Cal-2 results, shown by the dotted line in Figure 1a, have the same general downward trend until cycle 50 or so, after which the Cal-2 data seem to level off although there is still a slow gradual downward trend with time. The Ku-band Cal-1 data, shown by the solid line in Figure 1a, have the same general time trend as the sigma0(uncorr), but show slope differences around cycle 50 and then around cycle 118.

The C-band results in Figure 1b have a different Cal-2 behavior, nearly constant with time for cycles 001 to 162. We do not know why the Ku- and C-band Cal-2 results show such different behavior. The C-band Cal-1 data in Figure 1b show overall agreement with the C-band sigma0(uncorr), but there is still a puzzling C-band Cal-1 change around cycle 118.

Transmitted power monitor words for both the Ku- and the C-band in the TOPEX engineering data are also plotted as the uppermost data shown in Figures 1a and 1b. The transmitted power monitor variations are not large enough to explain the observed trends in the Cal-1 data relative to the sigma0(uncorr).

For the sigma0 calibration work reported in Callahan *et al.* [1994], we had decided that there were small anomalies in the Calibration Mode behavior, and that it would be more realistic to use time trends of global average over-ocean sigma0(uncorr) to produce the CalTable values; this remains our approach in the work reported here. There is some risk in this, because we do not want to remove actual changes in the global over-ocean sigma0. There are certainly annual variations in the global sigma0, and perhaps semiannual and higher frequency variations as well, so we want to use only longer term secular trends in the sigma0(uncorr) to provide the CalTable values. We will describe the CalTable values actually used in the production of the TOPEX GDRs to date, and then will describe the sigma0(uncorr) trend fitting.

History of CalTable Values Used in GDR Production

Early in the TOPEX mission there were zero values in Ku- and C-band CalTable. Eventually the sigma0(uncorr) appeared to be drifting downward, and two step corrections were put into the CalTable to compensate for the drift. Later in the mission the sigma0(uncorr) drift over time appeared to be linear, and the linear Ku- and C-band trends were used to predict further entries for the CalTable. The linear steps were first 0.05 dB, and then later the steps were provided at 0.03 dB increments. Recently (April 1996) a change in the linear trend became necessary.

Here is a summary of the CalTable changes for computing the TOPEX GDR Ku- and C-band sigma0 estimates (see also column 8 of Table 1):

* Initially, the CalTable values were zero.
* In January and March 1973, installed step corrections (reacting only after drift had occurred).
* In October 1994, began treating sigma0(uncorr) trends as linear in time, making corrections on 0.05 dB quantization. Used the current time trends to predict Cal Table values for 10 or so cycles into the future, at each MCR change. We described in Callahan *et al.* [1994] the linear trend back to cycle 001, for recorrecting the GDR estimates.
* In September 1995, continued treating sigma0(uncorr) trends as linear in time, but began making CalTable changes on 0.03 dB quantization.
* By May 1996, it became clear that the downward drift in sigma0(uncorr) departed from being purely linear with time, with downward slope greater for later cycles. Used step-

change in CalTable values and a new linear trend, still changing at 0.03 dB quantization. In September 1996 put in another jump and slope change.

* In October 1996, for both Ku- and C-band, fit the sigma0(uncorr) trend by set of line segments continuous in value but discontinuous in slope, with slope changes made on time scale no shorter than 1/2 year.
* In December 1996, the C-band sigma0(uncorr) data seemed to be departing from the trend already in the CalTable and the C-band Cal Table was temporarily frozen at one constant value for the next data cycles.
* Currently (March 1997) the Ku- and C-band Cal Table values are projected on a short-term linear trend quantized at 0.03 dB steps. The Ku-band slope is the same as before, but the C-band slope is new. The situation and the projected Cal Table values are to be reassessed at the completion of cycle 164.

Table 2a, columns 5 and 6, lists the Ku- and C-band CalTable values used in JPL's ground data processing to produce the originally-distributed TOPEX GDRs for cycles 001 through 162. Cycles 133-149 were reprocessed and re-released and Table 2b, columns 5 and 6, lists the Ku- and C-band CalTable values used in these reprocessed GDRs.

TREND FITTING OF SIGMA0 TO ESTIMATE CalTable VALUES

In the first three years of TOPEX/Poseidon, we had done a variety of least-squares fitting of global over-ocean sigma0(uncorr) cycle averages to a fit function whose parameters included 1) the amplitude and phase of both an annual and a semiannual sinusoid; 2) terms linear and quadratic in the Ku-band SWH; and 3) terms linear and quadratic in cycle number (equivalently, in time). In all sigma0(uncorr) trend-fitting we use data only from cycles 011 and higher. By assuming that the long-term true sigma0 should be constant, the CalTable values were taken as equal to the shifted negative values of the trend linear time term. These values were shifted to produce zero correction at cycle 011.

The current whole-mission sigma0(uncorr) seem to require at least a cubic polynomial for the time terms. We have used the SWH terms from the earlier work to adjust the sigma0(uncorr) for SWH before fitting a polynomial cubic in cycle number,

Kfit = Ku sigma0(uncorr) - dS*(Kcf1 + dS*Kcf2), and
Cfit = C sigma0(uncorr) - dS*(Ccf1 + dS*Ccf2),

where dS is the Ku-band SWH minus an average SWH (for cycles 11-122),

dS = SWH(Ku) - 2.844 m,

and Kcf1, Kcf2, Ccf1, and Ccf2 are coefficients whose values (from earlier trend fitting) are

Kcf1 = -0.4762 dB/m,
Kcf2 = +0.1802 dB/(m**2),
Ccf1 = -0.4014 dB/m, and
Ccf2 = +0.2880 dB/(m**2).

The Ku-band result from least-squares fitting the SWH-adjusted Kfit by a polynomial in cycle number is shown in Figure 2a where the asterisks show the SWH-adjusted sigma0(uncorr) and the

solid line shows the fitted polynomial. Similarly the C-band fit result is shown in Figure 2b. The negative shifted polynomial fit values are also listed in columns 7 and 8 of Table 2, for Ku- and C-band respectively; these are our current estimate of what the CalTable values should have been for each TOPEX altimeter data cycle.

To use our latest estimates to revise the TOPEX Ku-band GDR sigma0 values for GDRs already distributed, the data user should subtract the Table 2 column 5 value from his GDR sigma0 and then add the Table 2 column 7 value. In other words, the additive adjustment to the GDR Ku-band sigma0 is

Ku adjust = (Ku cubic fit, Table 2 column 7) minus (Ku CalTable, Table 2, column 5),

and this Ku sigma0 adjustment is plotted in Figure 3a.

Similarly, the TOPEX C-band additive adjustment is

C adjust = (C cubic fit, Table 2 column 8) minus (C CalTable, Table 2, column 6),

and this C-band sigma0 adjustment is plotted in Figure 3b. We referred here simply to Table 2, but the user has to decide whether to use Table 2a or Table 2b, depending on whether he has the originally distributed GDRs or has the reprocessed, re-distributed GDRS for cycles 133-149.

CONCLUSION AND SUMMARY

We have described (and listed in columns 5 and 6 of Table 2a and Table 2b) the CalTable values that were used in producing the already-distributed TOPEX GDRs, and then described the time trend fitting of sigma0(uncorr) to produce our polynomial fit results for the values which should have been in the CalTable. These revised values are a cubic function of time, and we provide these revised CalTable values in columns 7 and 8 of Table 2a and Table 2b. We have taken TOPEX cycle 11 as the zero reference, and our correction procedures compensate for the power measurement's longer-term drifts relative to cycle 11. We have described how to adjust the sigma0 values on already-distributed GDRs to our polynomial fitted values, and have plotted the Ku- and C-band additive sigma0 adjustments in Figure 3a and 3b.

REFERENCE

Callahan, P.S., D.W. Hancock,III, and G.S. Hayne, "New Sigma0 Calibration for the TOPEX Altimeter," TOPEX/POSEIDON Research News, pp.28-32, Issue 3, October 1994, JPL 410-42, Jet Propulsion Laboratory, Pasadena, CA

Table 1. MCR Information Summary

(1) MCR #	(2) MCR Originate Date	(3) Desired Operational Date	(4) Comments on MCR Form	(5) File Creation Date	(6) Release Approval Date	(7) File Execute to Begin *(cycle begin)*	(8) Comments on MCR actions and reasons	(9) Cycles Under This MCR
432	93/05/11 1993-131	93/05/12		93/05/12 1993-132 ?	93/05/12 ?	start of mission	At start of mission, had zeros in both Ku and C AGC table	001 - 047
492	94/01/10 1994-010	cycle 048 94/01/12	reprocess cycle 48 IGDRs, process all from 48 on using this file	94/01/10 1994-010 T18:05:00	94/01/12	94/01/02 1994-002 T04:28:00 *(cycle 048)*	First non-zero entries. Start applying to IGDRs at cycle 048, and add steps backward at cycles 015, 021, and 029.	048 - 055
501	94/03/30 1994-089	cycle 056 94/03/31	change to start at cycle 56 IGDRs	94/03/30 1994-089 T23:00:00	94/03/31	94/03/22 1994-081 T12:17:00 *(cycle 056)*	Add another step starting at cycle 056, keep rest of values same as MCR 492.	056 - 075
529	94/10/18 1994-291	cycle 076 94/10/19	use for cycle 76 IGDRs	94/10/17 1994-290 T14:00:00	94/10/19	94/10/06 1994-279 T19:47:00 *(cycle 076)*	Start at cycle 076, and replace earlier cycle values by linear ramp at 0.05 dB steps.	076 - 081
539	95/01/05 1995-005	95/01/04	reprocess cycle 80-83, use for 84 onward	95/01/04 1995-004 T19:40:00	95/01/04	94/12/05 1994-339 T07:38:00 *(cycle 082)*	Start at cycle 082. Extend linear ramp of MCR 529, predicting next cycles correction.	082 - 092
548	95/03/24 1995-083	cycle 93 95/03/29	use for cycle 93 IGDRs	95/03/29 1995-088 T21:20:00	95/03/29	95/01/13 1995-013 T23:32:43 *(cycle 086)*	Start at 093. Use linear prediction for next cycles, earlier values same as MCR 539. Note that begin exec. date is earlier than file creation, for reprocessing.	093 - 102
562	95/07/10 1995-191	95/07/12	use for cycle 103	95/07/10 1995-191 T20:52:00	95/07/11	95/07/01 1995-182 T13:07:39 *(cycle 103)*	Start at cycle 103 (a SSALT cycle). Extend linear ramp of MCR 548, predicting next cycles correction.	103 - 109
530	95/09/13 1995-256	95/09/15	use for cycle 110	95/09/14 1995-257 T18:10:00	95/09/15	95/09/08 1995-251 T22:57:19 *(cycle 110)*	Start at cycle 110. Refitted linear trend, extend backward, now using 0.03 dB steps.	110 - 121
585	95/12/13 1995-347	cycle 122 96/01/03	use for cycle 122	96/01/04 1996-004 T23:21:45	96/01/04	96/01/05 1996-005 T22:39:35 *(cycle 122)*	Start at cycle 122. Linear trend from MCR 530 was extended forward.	122 - 132
598	96/05/01 1996-122	cycle 133 96/05/01	hold cycle 133 IGDRs until update is made	96/05/01 1996-122 T21:21:10	96/05/01	96/04/24 1996-115 T00:23:25 *(cycle 133)*	At 133 put in a jump and a slope change to adapt to nonlinear time trend. Use MCR 585 values for cycles 001-132.	133 - 142
608	96/07/16 1996-198	cycle 143		96/07/22 1996-204 T17:30:30	96/07/24	96/08/01 1996-214 T04:08:38 *(cycle 143)*	Extend forward the trend started in MCR 598.	143 - 147
614	96/09/20 1996-264	96/09/25	use for cycle 148	96/09/25 1996-269 T16:30:00	96/09/25	96/09/19 1996-263 T18:01:15 *(cycle 148)*	At 148 put different jump and slope. Use MCR 608 values for cycles 001-147.	148 - 149
618	96/10/01 1996-275	96/10/02	use as part of reprocessing from cycle 133	96/10/07 1996-281 T17:31:00	96/10/07	96/09/19 1996-263 T18:01:15 *(cycle 148)*	Cycle 150 was SSALT. Execution date earlier than creation date for reprocessed 133-153 (#). Values same as MCR 614 for cycles 001-086, then different (line segment fit).	133 - 153# 151 - 153

Table 1. MCR Information Summary (continued)

(1) MCR #	(2) MCR Originate Date	(3) Desired Operational Date	(4) Comments on MCR Form	(5) File Creation Date	(6) Release Approval Date	(7) File Execute to Begin *(cycle begin)*	(8) Comments on MCR actions and reasons	(9) Cycles Under This MCR
629	96/12/04 1996-339	cycle 156 96/12/11	change before processing cycle 156	96/12/09 1996-344 T22:44:00	96/12/11	96/11/18 1996-323 T05:52:26 *(cycle 154)*	Keep Ku values of MCR 618, but freeze C-band value starting at cycle 154.	154 - 159
630	97/01/20 1997-020	97/01/22	use for cycle 160	97/01/22 1997-02 T16:44:00	97/01/22	97/01/16 1997-016 T17:43:34 *(cycle 160)*	Use new line segment fit, starting with cycle 160. Values same as MCR 629 until cycle 156.	160 - -

Table 2a. TOPEX CalTable Entries for Originally Released GDRs

(1) Data Cycle	(2) Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
1	1992-267	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
2	1992-277	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
3	1992-286	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
4	1992-296	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
5	1992-306	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
6	1992-316	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
7	1992-326	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
8	1992-336	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
9	1992-346	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
10	1992-356	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
11	1992-366	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
12	1993-010	mixed	MCR432	+0.00	+0.00	+0.007	+0.008
13	1993-020	mixed	MCR432	+0.00	+0.00	+0.015	+0.016
14	1993-030	mixed	MCR432	+0.00	+0.00	+0.022	+0.023
15	1993-039	mixed	MCR432	+0.00	+0.00	+0.030	+0.031
16	1993-049	mixed	MCR432	+0.00	+0.00	+0.037	+0.039
17	1993-059	NRA	MCR432	+0.00	+0.00	+0.044	+0.046
18	1993-069	NRA	MCR432	+0.00	+0.00	+0.051	+0.053
19	1993-079	NRA	MCR432	+0.00	+0.00	+0.059	+0.060
20	1993-089	SSALT					
21	1993-099	NRA	MCR432	+0.00	+0.00	+0.073	+0.074
22	1993-109	NRA	MCR432	+0.00	+0.00	+0.080	+0.081
23	1993-119	NRA	MCR432	+0.00	+0.00	+0.087	+0.088
24	1993-129	NRA	MCR432	+0.00	+0.00	+0.094	+0.095
25	1993-139	NRA	MCR432	+0.00	+0.00	+0.101	+0.101
26	1993-149	NRA	MCR432	+0.00	+0.00	+0.108	+0.108
27	1993-158	NRA	MCR432	+0.00	+0.00	+0.115	+0.114
28	1993-168	NRA	MCR432	+0.00	+0.00	+0.123	+0.120
29	1993-178	NRA	MCR432	+0.00	+0.00	+0.130	+0.127
30	1993-188	NRA	MCR432	+0.00	+0.00	+0.137	+0.133
31	1993-198	SSALT					
32	1993-208	NRA	MCR432	+0.00	+0.00	+0.151	+0.145
33	1993-218	NRA	MCR432	+0.00	+0.00	+0.157	+0.151
34	1993-228	NRA	MCR432	+0.00	+0.00	+0.164	+0.157
35	1993-238	NRA	MCR432	+0.00	+0.00	+0.171	+0.163
36	1993-248	NRA	MCR432	+0.00	+0.00	+0.178	+0.169
37	1993-258	NRA	MCR432	+0.00	+0.00	+0.185	+0.174
38	1993-268	NRA	MCR432	+0.00	+0.00	+0.192	+0.180

Table 2a. TOPEX CalTable Entries for Originally Released GDRs (continued)

(1) Data Cycle	(2) Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
39	1993-277	NRA	MCR432	+0.00	+0.00	+0.199	+0.186
40	1993-287	NRA	MCR432	+0.00	+0.00	+0.206	+0.191
41	1993-297	SSALT					
42	1993-307	NRA	MCR432	+0.00	+0.00	+0.220	+0.202
43	1993-317	NRA	MCR432	+0.00	+0.00	+0.227	+0.208
44	1993-327	NRA	MCR432	+0.00	+0.00	+0.234	+0.213
45	1993-337	NRA	MCR432	+0.00	+0.00	+0.241	+0.218
46	1993-347	NRA	MCR432	+0.00	+0.00	+0.248	+0.224
47	1993-357	NRA	MCR432	+0.00	+0.00	+0.255	+0.229
48	1994-002	NRA	MCR492	+0.25	+0.10	+0.262	+0.234
49	1994-012	NRA	MCR492	+0.25	+0.10	+0.269	+0.239
50	1994-022	NRA	MCR492	+0.25	+0.10	+0.276	+0.245
51	1994-031	NRA	MCR492	+0.25	+0.10	+0.283	+0.250
52	1994-041	NRA	MCR492	+0.25	+0.10	+0.290	+0.255
53	1994-051	NRA	MCR492	+0.25	+0.10	+0.297	+0.260
54	1994-061	NRA	MCR492	+0.25	+0.10	+0.304	+0.265
55	1994-071	SSALT					
56	1994-081	NRA	MCR501	+0.30	+0.15	+0.318	+0.276
57	1994-091	NRA	MCR501	+0.30	+0.15	+0.325	+0.281
58	1994-101	NRA	MCR501	+0.30	+0.15	+0.332	+0.286
59	1994-111	NRA	MCR501	+0.30	+0.15	+0.339	+0.291
60	1994-121	NRA	MCR501	+0.30	+0.15	+0.346	+0.296
61	1994-131	NRA	MCR501	+0.30	+0.15	+0.354	+0.301
62	1994-141	NRA	MCR501	+0.30	+0.15	+0.361	+0.306
63	1994-150	NRA	MCR501	+0.30	+0.15	+0.368	+0.311
64	1994-160	NRA	MCR501	+0.30	+0.15	+0.375	+0.317
65	1994-170	SSALT					
66	1994-180	NRA	MCR501	+0.30	+0.15	+0.390	+0.327
67	1994-190	NRA	MCR501	+0.30	+0.15	+0.397	+0.332
68	1994-200	NRA	MCR501	+0.30	+0.15	+0.405	+0.337
69	1994-210	NRA	MCR501	+0.30	+0.15	+0.412	+0.343
70	1994-220	NRA	MCR501	+0.30	+0.15	+0.420	+0.348
71	1994-230	NRA	MCR501	+0.30	+0.15	+0.427	+0.353
72	1994-240	NRA	MCR501	+0.30	+0.15	+0.435	+0.359
73	1994-250	NRA	MCR501	+0.30	+0.15	+0.442	+0.364
74	1994-259	NRA	MCR501	+0.30	+0.15	+0.450	+0.369
75	1994-269	NRA	MCR501	+0.30	+0.15	+0.458	+0.375
76	1994-279	NRA	MCR529	+0.45	+0.35	+0.465	+0.380

Table 2a. TOPEX CalTable Entries for Originally Released GDRs (continued)

(1) Data Cycle	(2) Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
77	1994-289	NRA	MCR529	+0.45	+0.35	+0.473	+0.386
78	1994-299	NRA	MCR529	+0.45	+0.35	+0.481	+0.392
79	1994-309	SSALT					
80	1994-319	NRA	MCR529	+0.45	+0.35	+0.497	+0.403
81	1994-329	NRA	MCR529	+0.45	+0.35	+0.504	+0.409
82	1994-339	NRA	MCR539	+0.50	+0.40	+0.512	+0.415
83	1994-349	NRA	MCR539	+0.50	+0.40	+0.520	+0.420
84	1994-359	NRA	MCR539	+0.50	+0.40	+0.529	+0.426
85	1995-004	NRA	MCR539	+0.50	+0.40	+0.537	+0.432
86	1995-013	NRA	MCR539	+0.55	+0.45	+0.545	+0.439
87	1995-023	NRA	MCR539	+0.55	+0.45	+0.553	+0.445
88	1995-033	NRA	MCR539	+0.55	+0.45	+0.561	+0.451
89	1995-043	NRA	MCR539	+0.55	+0.45	+0.570	+0.457
90	1995-053	NRA	MCR539	+0.55	+0.45	+0.578	+0.464
91	1995-063	SSALT					
92	1995-073	NRA	MCR539	+0.55	+0.45	+0.595	+0.477
93	1995-083	NRA	MCR548	+0.55	+0.45	+0.604	+0.483
94	1995-093	NRA	MCR548	+0.55	+0.45	+0.613	+0.490
95	1995-103	NRA	MCR548	+0.55	+0.45	+0.621	+0.497
96	1995-113	NRA	MCR548	+0.55	+0.45	+0.630	+0.504
97	1995-123	SSALT					
98	1995-132	NRA	MCR548	+0.55	+0.45	+0.648	+0.518
99	1995-142	NRA	MCR548	+0.60	+0.45	+0.657	+0.525
100	1995-152	NRA	MCR548	+0.60	+0.45	+0.666	+0.533
101	1995-162	NRA	MCR548	+0.60	+0.45	+0.675	+0.540
102	1995-172	NRA	MCR548	+0.60	+0.45	+0.684	+0.548
103	1995-182	SSALT					
104	1995-192	NRA	MCR562	+0.65	+0.50	+0.703	+0.563
105	1995-202	NRA	MCR562	+0.65	+0.50	+0.713	+0.571
106	1995-212	NRA	MCR562	+0.65	+0.50	+0.722	+0.579
107	1995-222	NRA	MCR562	+0.70	+0.55	+0.732	+0.588
108	1995-232	NRA	MCR562	+0.70	+0.55	+0.741	+0.596
109	1995-242	NRA	MCR562	+0.70	+0.55	+0.751	+0.604
110	1995-251	NRA	MCR530	+0.75	+0.57	+0.761	+0.613
111	1995-261	NRA	MCR530	+0.75	+0.57	+0.771	+0.622
112	1995-271	NRA	MCR530	+0.75	+0.60	+0.781	+0.630
113	1995-281	NRA	MCR530	+0.75	+0.60	+0.791	+0.639
114	1995-291	SSALT					

Table 2a. TOPEX CalTable Entries for Originally Released GDRs (continued)

(1) Data Cycle	(2) Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
115	1995-301	NRA	MCR530	+0.78	+0.60	+0.812	+0.658
116	1995-311	NRA	MCR530	+0.78	+0.60	+0.822	+0.667
117	1995-321	NRA	MCR530	+0.78	+0.63	+0.833	+0.677
118	1995-331	NRA	MCR530	+0.81	+0.63	+0.833	+0.677
119	1995-341	NRA	MCR530	+0.81	+0.63	+0.854	+0.697
120	1995-351	NRA	MCR530	+0.81	+0.63	+0.865	+0.707
121	1995-361	NRA	MCR530	+0.81	+0.63	+0.875	+0.717
122	1996-005	NRA	MCR585	+0.84	+0.63	+0.886	+0.727
123	1996-015	NRA	MCR585	+0.84	+0.66	+0.898	+0.738
124	1996-025	NRA	MCR585	+0.84	+0.66	+0.909	+0.748
125	1996-035	NRA	MCR585	+0.84	+0.66	+0.920	+0.759
126	1996-045	SSALT					
127	1996-055	NRA	MCR585	+0.87	+0.66	+0.943	+0.782
128	1996-065	NRA	MCR585	+0.87	+0.69	+0.954	+0.793
129	1996-075	NRA	MCR585	+0.87	+0.69	+0.966	+0.805
130	1996-085	NRA	MCR585	+0.90	+0.69	+0.978	+0.816
131	1996-095	NRA	MCR585	+0.90	+0.69	+0.990	+0.828
132	1996-105	NRA	MCR585	+0.90	+0.69	+1.002	+0.841
133	1996-115	NRA	MCR598	+0.99	+0.78	+1.014	+0.853
134	1996-124	NRA	MCR598	+0.99	+0.78	+1.026	+0.866
135	1996-134	NRA	MCR598	+1.02	+0.78	+1.038	+0.878
136	1996-144	NRA	MCR598	+1.02	+0.81	+1.051	+0.891
137	1996-154	NRA	MCR598	+1.02	+0.81	+1.064	+0.904
138	1996-164	SSALT					
139	1996-174	NRA	MCR598	+1.05	+0.81	+1.089	+0.931
140	1996-184	NRA	MCR598	+1.05	+0.84	+1.102	+0.945
141	1996-194	NRA	MCR598	+1.08	+0.84	+1.115	+0.959
142	1996-204	NRA	MCR598	+1.08	+0.84	+1.128	+0.973
143	1996-214	NRA	MCR608	+1.08	+0.87	+1.142	+0.988
144	1996-224	NRA	MCR608	+1.11	+0.87	+1.155	+1.003
145	1996-234	NRA	MCR608	+1.11	+0.87	+1.169	+1.017
146	1996-243	NRA	MCR608	+1.11	+0.87	+1.182	+1.033
147	1996-253	NRA	MCR608	+1.14	+0.90	+1.196	+1.048
148	1996-263	NRA	MCR614	+1.23	+1.02	+1.210	+1.063
149	1996-273	NRA	MCR614	+1.23	+1.02	+1.224	+1.079
150	1996-283	SSALT					
151	1996-293	NRA	MCR618	+1.29	+1.17	+1.253	+1.112
152	1996-303	NRA	MCR618	+1.32	+1.20	+1.267	+1.128

Table 2a. TOPEX CalTable Entries for Originally Released GDRs (continued)

(1) Data Cycle	(2) Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
153	1996-313	NRA	MCR618	+1.32	+1.23	+1.282	+1.145
154	1996-323	NRA	MCR629	+1.35	+1.26	+1.296	+1.162
155	1996-333	NRA	MCR629	+1.35	+1.26	+1.311	+1.179
156	1996-343	NRA	MCR629	+1.38	+1.26	+1.326	+1.197
157	1996-352	NRA	MCR629	+1.38	+1.26	+1.342	+1.215
158	1996-362	NRA	MCR629	+1.41	+1.26	+1.357	+1.233
159	1997-006	NRA	MCR629	+1.41	+1.26	+1.372	+1.251
160	1997-016	NRA	MCR630	+1.41	+1.29	+1.388	+1.269
161	1997-026	NRA	MCR630	+1.41	+1.29	+1.404	+1.288
162	1997-036	SSALT					

Table 2b. TOPEX CalTable Entries for Reprocessed and Rereleased GDRs

(1) Data Cycle	(2) Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
133	1996-115	NRA	MCR618	+1.05	+0.81	+1.014	+0.853
134	1996-124	NRA	MCR618	+1.05	+0.81	+1.026	+0.866
135	1996-134	NRA	MCR618	+1.08	+0.84	+1.038	+0.878
136	1996-144	NRA	MCR618	+1.08	+0.84	+1.051	+0.891
137	1996-154	NRA	MCR618	+1.08	+0.84	+1.064	+0.904
138	1996-164	SSALT					
139	1996-174	NRA	MCR618	+1.11	+0.90	+1.089	+0.931
140	1996-184	NRA	MCR618	+1.14	+0.93	+1.102	+0.945
141	1996-194	NRA	MCR618	+1.14	+0.93	+1.115	+0.959
142	1996-204	NRA	MCR618	+1.17	+0.96	+1.128	+0.973
143	1996-214	NRA	MCR618	+1.17	+0.99	+1.142	+0.988
144	1996-224	NRA	MCR618	+1.20	+1.02	+1.155	+1.003
145	1996-234	NRA	MCR618	+1.20	+1.05	+1.169	+1.017
146	1996-243	NRA	MCR618	+1.23	+1.05	+1.182	+1.033
147	1996-253	NRA	MCR618	+1.23	+1.08	+1.196	+1.048
148	1996-263	NRA	MCR618	+1.26	+1.11	+1.210	+1.063
149	1996-273	NRA	MCR618	+1.26	+1.14	+1.224	+1.079

Figure 1a. Ku Cycle-Avg Cal-1 and Cal-2 Delta AGC and Sigma0
(Cal Table Corrections Removed)

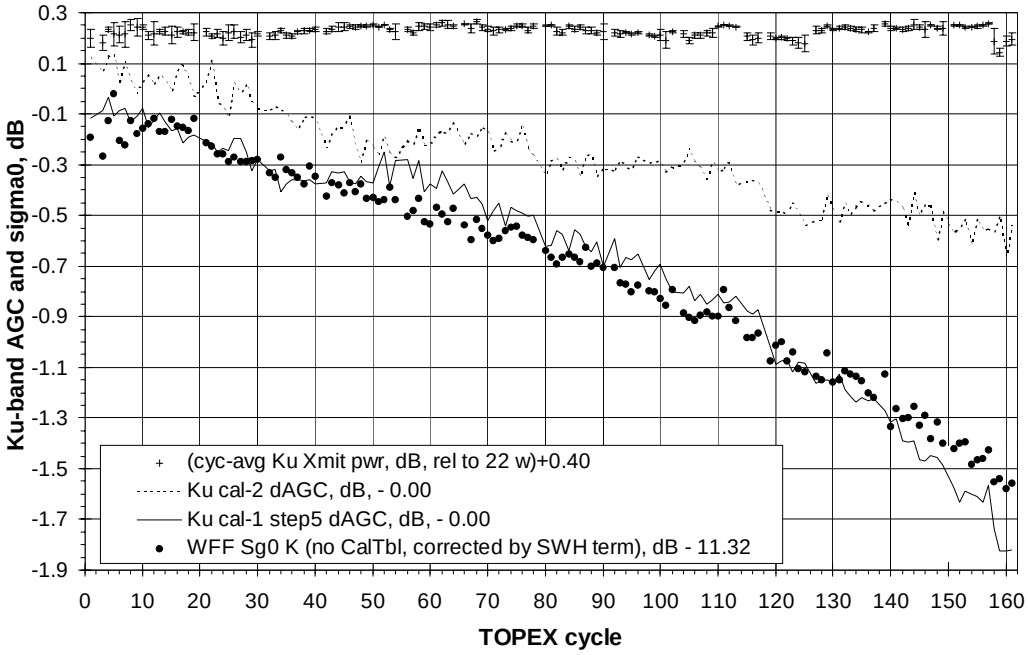


Figure 1b. C-Band Cyc-Avg Cal-1 and Cal-2 Delta AGC and Sigma0
(Cal Table Corrections Removed)

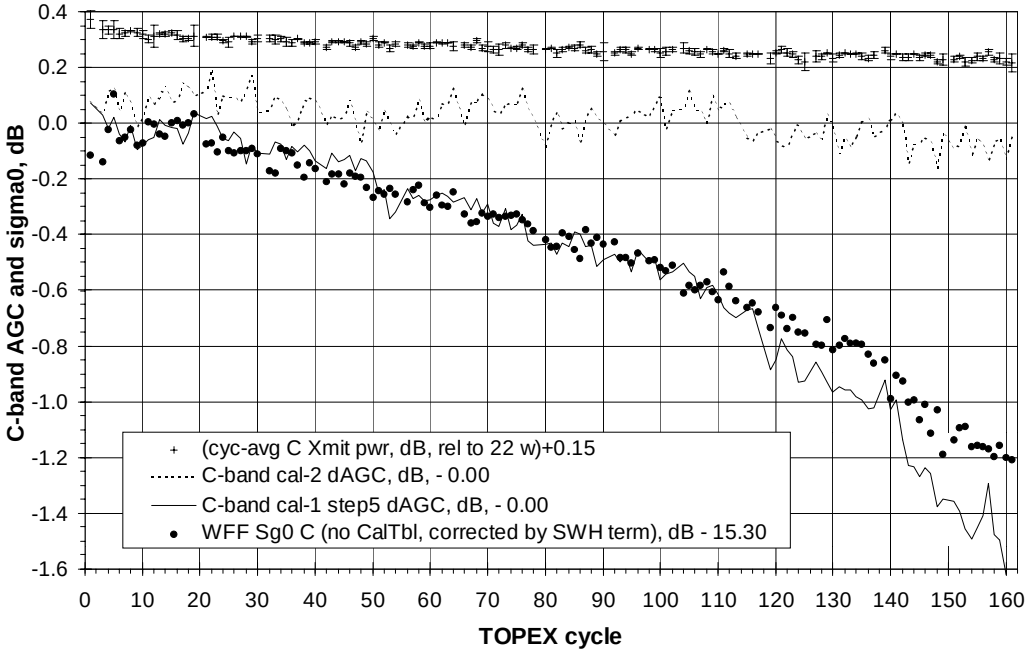
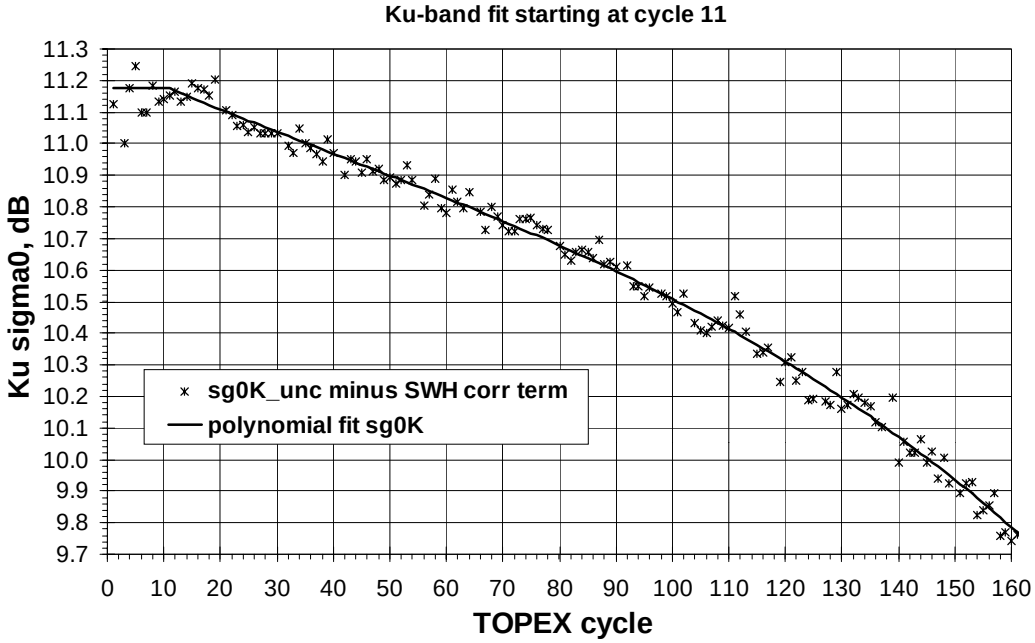


Figure 2a. Ku Sigma0 (SWH-Corr, CalTable Removed)



.

Figure 2b. C Sigma0 (SWH-Corr, CalTable Removed)

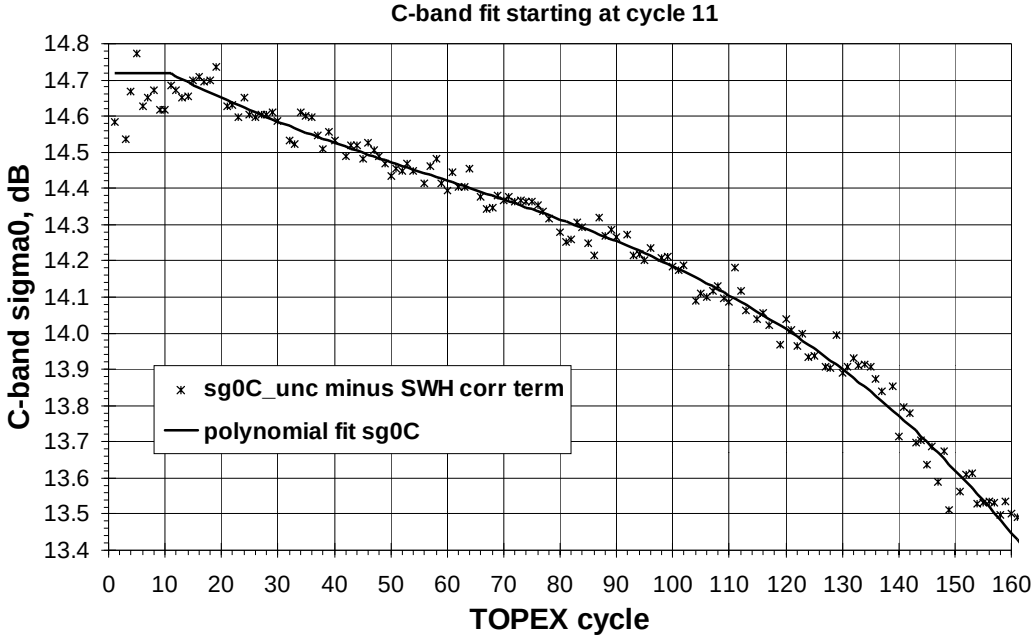


Figure 3a. Ku-Band Additive Adjustment to GDR Sigma0 Values
o = originally distributed GDRs * = reprocessed, redistributed GDRs

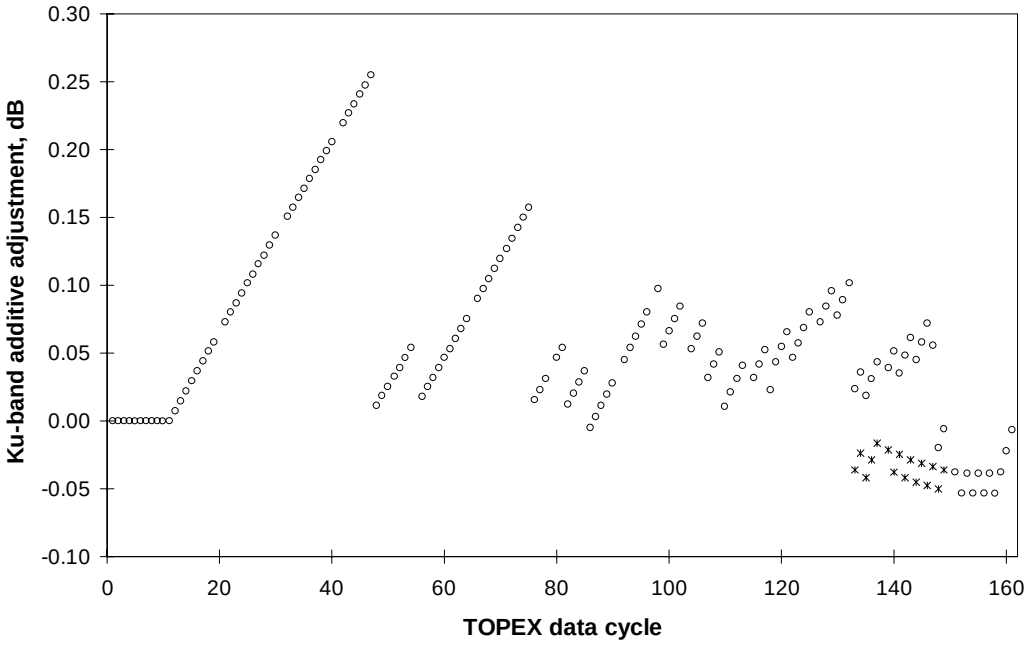


Figure 3b. C-Band Additive Adjustment to GDR Sigma0 Values
o = originally distributed GDRs * = reprocessed, redistributed GDRs